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DECLARATION UNDER 37 C.F.R. 1.132

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re Patent Application of:

DuckChul HWANG et al.

Group Art Unit: 1745

Serial No: 09/910,952

Examiner: Laura S Weiner

Confirmation No. 3638

Filed: July 24, 2001

For: ELECTROLYTE FOR A LITHIUM-SULFUR BATTERY AND A LITHIUM-SULFUR BATTERY USING THE SAME

Declaration Under Rule 132

Commissioner for Patents  
PO Box 1450  
Alexandria, VA 22313-1450

Dear Sir:

I, DuckChul HWANG, have reviewed the above identified patent application, references, and arguments set forth in the Office Action and declare as follows:

1. I have received a bachelor's degree in chemistry from Yonsei University in 1996 and a master's degree in chemistry also from Yonsei University in 1998 and have 6 years of experience in the field of lithium secondary batteries, especially lithium sulfur batteries and am aware of the state of the art from the time of 1998 to 2003. I have filed 41 Korean Patent Applications (28 of which are Registered) and 14 US Patent Applications (4 of which are registered) related to electrolytes and/or batteries.
2. I have reviewed and understand the references, the claims, and the arguments in the Office Action;
3. I have reviewed the references relied upon by the Examiner, Simon et al. (U.S. Patent No. 5,626,981), Skothelm et al. (U.S. Patent No. 5,961,672), and Dahn et al. (U.S. Patent No. 5,041,347), and note that none of these references disclose an electrolyte including "a first solvent having a dielectric constant that is greater than or equal to 20," "a second solvent having a viscosity that is less than or equal to 1.3," and "an electrolyte salt," where "the first solvent is roughly between 20% and 40 % by weight of the electrolyte, and the second solvent is roughly between 80% and about 60 % by weight of the electrolyte." Claims 10 through 12 recite similar range limitations.
4. At most, these references, alone or in combination, disclose using the following:
  - a. a 1:1 ratio as in Examples 1 through 4 in Simon et al. (U.S. Patent No. 5,626,981); or

- b. using only 10% of sulfolane in a mixed electrolyte with the remainder being classifiable as a second solvent as set forth in Examples 3 and 4 of Skotheim et al. (U.S. Patent No. 5,961,672).
5. The difference in the ranges disclosed in the prior art and the ranges recited in claims 4 and 10-12 is significant in that, as noted in paragraph 0025 of the instant application, if more than 80 % by volume [of the first solvent having the high dielectric constant] is used, the discharge capacity abruptly decreases." In such a ratio, "since the first solvent has the high polarity, it is not likely to impregnate in a separator with a low polarity." Moreover, the "difficulty of the impregnation may also reduce the discharge capacity in the case that the first solvent is used with more than 80 % by volume."
6. Moreover, Battery cells comprising electrolytes having the first/second solvent mixed ratio within 20-40/ 80-60 as recited in claims 4 and 10-12 show improved electrochemical properties as compared to those comprising electrolytes having the first/second solvent mixed ratio out of 20-40/ 80-60. Specifically, on August 2003 at laboratory of Samsung SDI, I performed the following experiment to evidence this result:
  - a. 60 % of an elemental sulfur, 20 % of a super P conductive material, and 20 % of a poly(vinyl acetate) were mixed in an acetonitrile solvent until a slurry was evenly mixed;
  - b. the slurry was coated on an Al current collector coated with carbon;
  - c. before fabricating the coated positive electrode, the coated positive electrode was dried for more than 12 hours under vacuum;
  - d. the positive electrode and a vacuum-dried separator were transferred to a glove box;
  - e. a proper amount of an electrolyte comprising 1 M of  $\text{LiSO}_3\text{CF}_3$  as a salt was placed on the positive electrode;
  - f. the separator was placed on the positive electrode, a small amount of the electrolyte was added, and the lithium electrode was placed thereon; and
  - g. after staying 24 hours at room temperature, the fabricated batteries underwent charging/discharging for 1 cycle at 0.1C, 3 cycles at 0.2C, 5 cycles at 0.5C, and 100 cycles at 1.0C under 1.5 V to 2.8V of cut-off voltage.
7. The composition of electrolyte and the result of charging/discharging cycle are shown in Table 1 below:

Table 1

Electrolyte (ratio)	Cycle life characteristic (100cycles/Initial)%	Initial discharge capacity (mAh/g)
Propylene carbonate/2-methyl tetrahydrofuran (20/80)	85 %	658
Propylene carbonate/2-methyl tetrahydrofuran (30/70)	70 %	637
Propylene carbonate/2-methyl tetrahydrofuran (40/60)	65 %	632

Electrolyte (ratio)	Cycle life characteristic (100cycles/initial)%	Initial discharge capacity (mAh/g)
Propylene carbonate/2-methyl tetrahydrofuran (50/50)	63 %	625
Propylene carbonate/2-methyl tetrahydrofurane (60/40)	51 %	593
Propylene carbonate/2-methyl tetrahydrofuran (70/30)	36 %	552
Propylene carbonate/2-methyl tetrahydrofuran (80/20)	25 %	436
Propylene carbonate/2-methyl tetrahydrofuran (90/10)	18 %	274

8. As can be seen from the results of Table 1, where a ratio of the first solvent having a dielectric constant is at most 40% of the electrolyte and the second solvent having a viscosity that is less than or equal to 1.3 is at least 60%, there is an improvement in both cycle life characteristics and initial discharge capacities as compared to where more than 40% of the first solvent is used as disclosed in the prior art Examples relied upon by the Examiner.
9. Moreover, at the time of the invention, I was not aware of a suggestion that such an improvement would occur. Therefore, that the improvement described above was not expected. Simon et al. (U.S. Patent No. 5,626,981), Skotheim et al. (U.S. Patent No. 5,961,672), and Dahn et al. (U.S. Patent No. 5,041,347) similarly fail to teach using less than 40% and more than 20% of a solvent classifiable as the first solvent of claim 4 such that there was no reason for one of ordinary skill in the art to see such a result. For similar reasons, there was no reason for one of ordinary skill in the art to see such a result for the recited ranges in claims 10-12

The Declarant further states that the above statements were made with the knowledge that willful false statements and the like are punishable by fine and/or imprisonment, or both, under Section 1001 of Title 18 of the United States Code, and that any such willful false statement may jeopardize the validity of this application or any patent resulting therefrom.

By: \_\_\_\_\_

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Date 2003. 9. 29